NOTES FROM PACIFIC COAST OBSERVATORIES.

THE ORBITS OF THE CEPHEID VARIABLES Y SAGITTARII AND RT AURIGÆ; WITH A DISCUSSION OF THE POSSIBLE CAUSES OF THIS TYPE OF STELLAR VARIATION.[1]

Of the several classes into which variable stars have been divided, only two—the Algol stars and the *Cepheid-Geminid* stars—have been shown to be distinguished by variable radial velocity. Of the nature and cause of variation in the Algol stars there can be no reasonable doubt, since all their observed phenomena point to the occurrence of stellar eclipses. The case of the *Cepheids* and *Geminids*,[2] however—I wish to treat the two classes as one—is by no means clear; and, since a number of these stars are bright enough for spectrographic work and as all so far investigated have been found to possess an orbital motion, there seems to be in this, one of the most vulnerable points for attacking the problem of stellar variability.

In order to give weight to any hypothesis regarding the cause of continuous variation, we must have a knowledge of the orbits of as many stars as possible; and to this end Director CAMPBELL has suggested several stars of this type as subjects for special work by individual observers with the great refractor. Such a piece of work is described in the present paper.

Y SAGITTARII.

The variability of brightness of Y *Sagittarii* was discovered by SAWYER in 1886. Since then its brightness has been ob-

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[1] Abstract from dissertation, published in full in *Lick Observatory Bulletin*, 151, 5, 82, 1909.

[2] These names, derived from those of the type-stars δ *Cephei* and ζ *Geminorum*, seem to have originated with Miss CLERKE. The light of both classes varies continuously, but the light-curves of the *Cepheids* are steepest on the rise from minimum to maximum, while in the *Geminids* a minimum occurs midway between two maxima.

served by SAWYER, CHANDLER, YENDELL, LUIZET, and PICK-
ERING, so that the nature and period of its variation have been
established with considerable accuracy. The star's binary char-
acter was announced by CURTISS[3] in 1904.

The position for 1900.0 is $\alpha = 18^h \ 15^m.5$, $\delta = -18° \ 54'$; the
light variation, according to CHANDLER, is from 6.6 magnitude
to 5.8·magnitude; according to PICKERING, from 6.2 magni-
tude to 5.4 magnitude. The class is *Cepheid* and the spectral
type approximately solar. From the observations of CHAN-
DLER and PICKERING, covering an interval of about twelve
years, the period of variation was determined as $5^d.77336$.

The spectrograms on which my orbital elements depend were
obtained with the 36-inch refractor and the single-prism spec-
trograph ordinarily used at this observatory for stars too faint
for the three-prism instrument. The comparison spectrum was
furnished by the iron spark, using self-induction to eliminate
the air lines. Two different kinds of plates were used—Seed's
"27" and Lumière's "Sigma." The former have somewhat the
finer grain, but the latter are considerably the faster. I ob-
tained thirty-three plates in all, but owing to underexposure
six of these were unfit for use.

These spectrograms exhibit the peculiarity noted by
ALBRECHT[4] in the spectra of other stars of this class, the
maximum intensity of the continuous spectrum being shifted
toward the violet as the star's light approached a maximum
and back toward the red as it approached a minimum.

The plates were measured with a Hartmann spectrocom-
parator.[5] As the instrument had not been used before, it was
first necessary to investigate the errors of the screw. This was
done in the manner described by HARTMANN[6] and the screw
found to be very good, though there is indication of a slight
periodic error. This error was, however, eliminated in meas-
uring the plates by turning the screw through a half revolu-
tion between the direct and reverse measures. As a funda-

[3] *Lick Observatory Bulletin*, **3**, 31, 1904; and *Astrophysical Journal*, **22**, 274,
1905.

[4] *Lick Observatory Bulletin*, **4**, 131, 1907.

[5] See article by Dr. J. H. MOORE, *Publications A. S. P.*, **19**, 24, 1907.

[6] *Publicationen des Astrophysikalischen Observatoriums zu Potsdam*, **18**, I.

mental plate I used a spectrogram of the sky, photographed on a Seed "27" plate, 1908, June 29th.

From the twenty-seven plates measured, the following elements were derived by the method of LEHMANN-FILHÉS:—

ORBITAL ELEMENTS OF Y *SAGITTARII.*

Period	$U = 5^d.77336$
Mean daily motion	$\mu = 62°.3554$
Time of periastron passage	$T = 4^d.46$ after light-max.
Distance of periastron from node	$\omega = 32°\ 00'$
Eccentricity	$e = 0.16$
Velocity of system	$V = + 4.0^{km}$
Maximum radial velocity	$= + 25.2^{km}$
Minimum radial velocity	$= - 12.4^{km}$
Single amplitude of curve	$K = 19.0^{km}$
Projection of semi-major axis	$a \sin i = 1,485,000^{km}$

Within the errors of observation, there is no evidence of any irregularities in the velocity-curve, such as appear so strikingly in the curves of ζ *Geminorum*[7] and W *Sagittarii.*[8]   It is noteworthy that the time interval between maximum light and maximum velocity of approach is unusually long for a variable of this class.

RT *AURIGÆ.*

The light-variability of RT *Aurigæ,* a star formerly known by FLAMSTEED's designation of 48 *Aurigæ,* was discovered by Mr. T. H. ASTBURY in March, 1905.[9]   Two light-curves have been published, a preliminary one by WILLIAMS[10] and a more nearly definitive one by ASTBURY.[11]

From the discoverer's papers in the *Journal of the British Astronomical Association* are derived the following data:—

α 1900, 6^h $22^m.1$; δ 1900.0, $+ 30°\ 34'$; max., $4^m.93$; min., $5^m.91$; time from max. to min., $2^d.51$; period, $3^d.7282$; epoch of max., J. D. 2417173.36; class, *Cepheid.*

The spectral type is very approximately solar.

[7] CAMPBELL, *Astrophysical Journal,* **13,** 90, 1901.

[8] CURTISS, *Astrophysical Journal,* **22,** 274, 1905; and *Lick Observatory Bulletin,* **3,** 36, 1904.

[9] *Journal of the British Astronomical Association,* **15,** 244, 1905.

[10] *Journal of the British Astronomical Association,* **15,** 270, 1905.

[11] *Journal of the British Astronomical Association,* **18,** 85, 1907; and **18,** 132, 1907.

The density of three preliminary plates of this star obtained with the single-prism spectrograph early in August indicated that it was bright enough for investigation with the three-prism instrument, and work with the latter was accordingly begun in September. On account of the star's faintness it was necessary to use Lumière's very rapid but coarse-grained "Sigma" plates and to open the slit much wider than is customary in using this spectrograph. Under these conditions the exposures varied from about one and three-fourths to three and one-half hours, depending upon the state of the air and the light phase of the star.

For the measurement of the plates I used the spectrocomparator and, as fundamental plate, a spectrogram of the sky was made on a Seed "27" plate, 1908, September 28th. The greater number of settings on each plate combined with the greater dispersion of the spectrograph to make the accuracy of the velocities derived from plates of this star much greater than that of the velocities determined for Y *Sagittarii*.

Twenty-six measurable plates were obtained, but in determining the velocity curve only twenty-two were used, though two of the remaining four give reasonably small residuals. Three of the unused four are much underexposed and the fourth was discarded because of its large residual, since three other plates in the same part of the curve give small residuals.

The orbital elements derived from the velocity-curve by the method of LEHMANN-FILHÉS are:—

<div align="center">PRELIMINARY ELEMENTS OF RT <i>AURIGÆ</i>.</div>

Period	$U = 3^{\mathrm{d}}.7282$
Mean daily motion	$\mu = 96°.5615$
Time of periastron passage	$T = 3^{\mathrm{d}}.40$ after light-max.
Distance of periastron from node	$\omega = 92° \ 2'$
Eccentricity	$e = 0.36$
Velocity of system	$V = + 21.50^{\mathrm{km}}$
Maximum radial velocity	$= + 38.54^{\mathrm{km}}$
Minimum radial velocity	$= + 4.02^{\mathrm{km}}$
Single amplitude of curve	$K = 17.26^{\mathrm{km}}$
Projection of semi-axis major	$a \sin i = 825,500^{\mathrm{km}}$

Since publishing my original article, I have made a least-squares solution for the orbit of this star, obtaining the following final elements:—

FINAL ELEMENTS OF RT *AURIGÆ*.

Time from light-max. to periastron	$T = 3^{d}.423 \pm 0^{d}.020$
Distance of periastron from node	$\omega = 95°.016 \pm 2° \, 502$
Eccentricity	$e = 0.368 \pm 0.014$
Velocity of system	$V = + 21^{km}.434 \pm 0.399$
Maximum radial velocity	$= + 38^{km}.819$
Minimum radial velocity	$= + \; 2^{km}.895$
Single amplitude of curve	$K = 17^{km}.962 \pm 0^{km}.246$
Projection of semi-axis major	$a \sin i = 856,500^{km}$

By the least-squares solution the sum of the squares of the residuals was reduced from 28.69 to 22.05. The outstanding residuals are so grouped as to suggest that the orbit is nòt truly elliptic.

THEORIES CONCERNING THE CAUSE OF LIGHT CHANGE IN *CEPHEID* AND *GEMINID* VARIABLES.

Twelve stars whose light variation is continuous and of short period have now been investigated spectrographically with a considerable degree of completeness. We shall consider the various explanations that have been suggested as to the cause of their variability and test these explanations, as far as possible, by means of the observed facts.

The principal characteristics of stars of this type are:—

1. Their light varies without pause.
2. The amount of their light variation is usually about one magnitude.
3. Their periods are short—a few days only.
4. They are of a spectral type approximately solar; no Orion, Sirian, or Antarian stars having been found among them.
5. They seem to be found in greater numbers in certain parts of the sky, notably in the Milky Way,[13] but exhibit no tendency to form close clusters.
6. All those stars whose radial velocities have been studied have been found to be binaries, whose period of orbital revolution coincides with that of their light change.
7. The orbits, so far as determined, are all small, $a \sin i$ being $2,000,000^{km}$ or less.

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[13] Miss CLERKE, *System of the Stars,* 144, 1890.